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MANNED SPACE FLIGHT

PROJECTS MERCURY AND GEMINI

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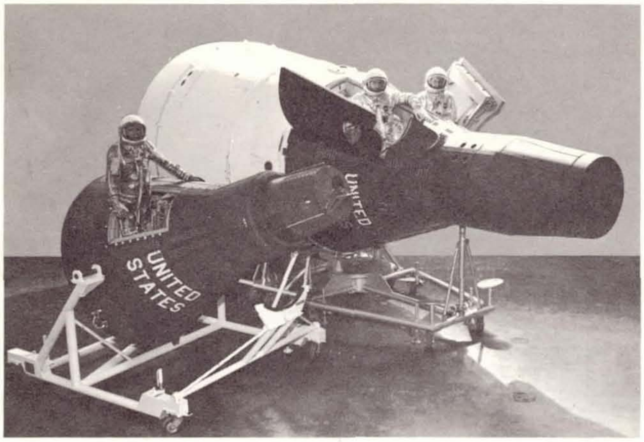
Astronauts Virgil I. Grissom (left) and John W. Young (right) in pressure suits climb into the Gemini Procedures Trainer for a flight test profile and training session in preparation for the first manned Gemini flight.



Mercury one-man spacecraft alongside mock-up of two-man Gemini.

MANNED SPACE FLIGHT

A major goal of the United States space program is manned space flight to the moon, and safe return to earth of the astronauts, before the end of this decade.

NASA's manned space flight program has been divided into three big steps, or projects—Mercury, Gemini, and Apollo.

Already accomplished, Project Mercury paved the way by using experimental one-man vehicles and proving that men could be sent into space and returned safely to earth.

Project Gemini's two-man spacecraft will fulfill a two-part plan: first, extending orbit missions up to 2 weeks at a time; second, developing the technique of rendezvous and docking, during which two space vehicles are maneuvered close together and finally joined, or "docked."

That same technique of orbit rendezvous—but around the moon instead of earth—will enable astronauts in the three-man Project Apollo spacecraft to achieve lunar landings .

PROJECT MERCURY

Project Mercury became an official program of NASA on November 26, 1958. A Space Task Group to initiate this new venture was formed at Langley Field, Virginia. This group evolved into the Manned Spacecraft Center, Houston, Texas and after a nationwide call for jet pilot volunteers, seven astronauts were chosen in April 1959.

The one-man Mercury spacecraft was designed and built with a maximum orbiting weight of about 3,200 pounds. Shaped somewhat like a bell (truncated cone), the craft is 74.5 inches wide across the bottom and about 9 feet tall. The astronaut escape tower on top adds another 17 feet for an overall length of approximately 26 feet at launch. Two boosters were chosen—the Army's Redstone (78,000 lbs. thrust) and Air Force's Atlas (360,000 lbs. thrust)—for suborbital and orbital flights, respectively. Before the manned flights began, Ham, the chimp, successfully achieved a suborbital Mercury-Redstone 2 (MR–2) flight on January 31, 1961.

Then all was ready for the historic MR–3 flight of May 5, 1961, as Astronaut Alan B. Shepard, Jr., made the first U.S. manned space flight. His suborbital mission of 19 minutes took his Freedom 7 spacecraft 116 miles high into space.

After another countdown for MR–4 on July 21, 1961, the Redstone booster hurled Astronaut Virgil I. "Gus" Grissom through the second ballistic (suborbital) flight in the Liberty Bell 7.

This ended the Redstone non-orbital tests as the Mercury-Atlas series of flights advanced to orbital missions. Again preceding the first manned attempt the chimp Enos made an orbital flight (MA–5) on November 29, 1961.

An MA–6 space milestone, on February 20, 1962, made Astronaut John H. Glenn, Jr., the first American in orbit, completing three circuits in Friendship 7.

On the MA–7 mission of May 24, 1962, Astronaut M. Scott Carpenter in Aurora 7 completed another three-orbit flight.

MA–8 of October 3, 1962, doubled the flight time in space as Astronaut Walter M. Schirra, Jr., orbited six times, landing Sigma 7 in the Pacific recovery area, instead of the Atlantic.

Finally, on May 15–16, 1963, Astronaut L. Gordon Cooper, Jr.'s Faith 7 completed a 22-orbit mission of 34½ hours, triumphantly concluding the flight phase of Project Mercury. The technical report, "Mercury Project Summary" was published in October 1963, five years after the project began.

Originally, Project Mercury was assigned only two broad missions by NASA—first, to investigate man's ability to survive and perform in the space environment; and second, to develop the basic space technology and hardware for manned space flight programs to come.

Beyond these basic goals, Mercury accomplished the following: developed a *NASA management system* to carry on more advanced manned space flight ventures; explored the fundamentals of *spacecraft reentry;* started a family of *launch vehicles* from existing rockets that led to new booster designs; expanded the *aerospace industry* by NASA contracting; set up an earth-girdling *tracking system;* trained a *pool of astronauts* easily augmented for future space exploration programs.

PROJECT GEMINI

Project Gemini was named after the twin stars Castor and Pollux in the constellation Gemini.

NASA decided to follow the Mercury's basic "capsule" design for Gemini spacecraft, saving time and engineering efforts. But the two-man craft is wider (7.5 feet), taller (11.5 feet), and more than twice as heavy (7700 lbs.). These dimensions give 50 percent more cabin space, making room for much new equipment and with it far greater performance flexibility.

Since Mercury's Redstone and Atlas boosters lacked the power to orbit the heavier two-man craft, a modified version of the military Titan II became the Gemini Launch Vehicle (GLV), with a total thrust of 530,000 pounds (first stage, 430,000 pounds). The hypergolic (self-igniting) propellants used are non-explosive, an astronaut safety factor.

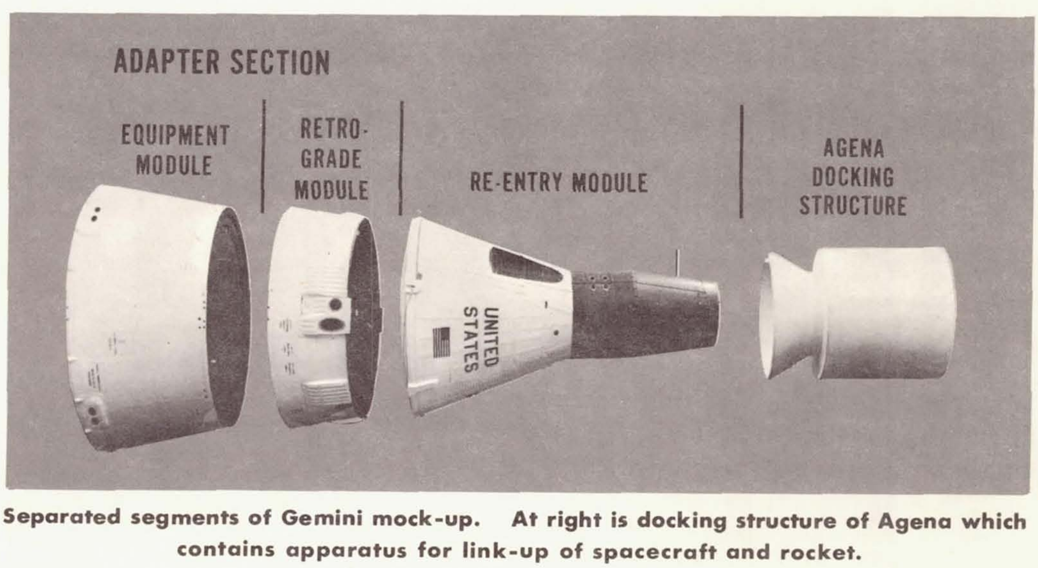
Chosen for Gemini's prime mission of orbital rendezvous and docking was the Agena–D "target" vehicle, a new version of the reliable Agena–B second-stage that, with Thor or Atlas boosters, had orbited many satellites and launched Mariner and Ranger probes. Agena's "stop-and-restart" rocket engine, capable of cutoff and reignition at least four times, is important for rendezvous maneuvers with Gemini. The hypergolic propellants are hydrazine and nitrogen tetroxide.

Agena–D is 32 feet long and 5 feet in diameter, is shaped like a cylinder and tapered at the front end to a blunt point.

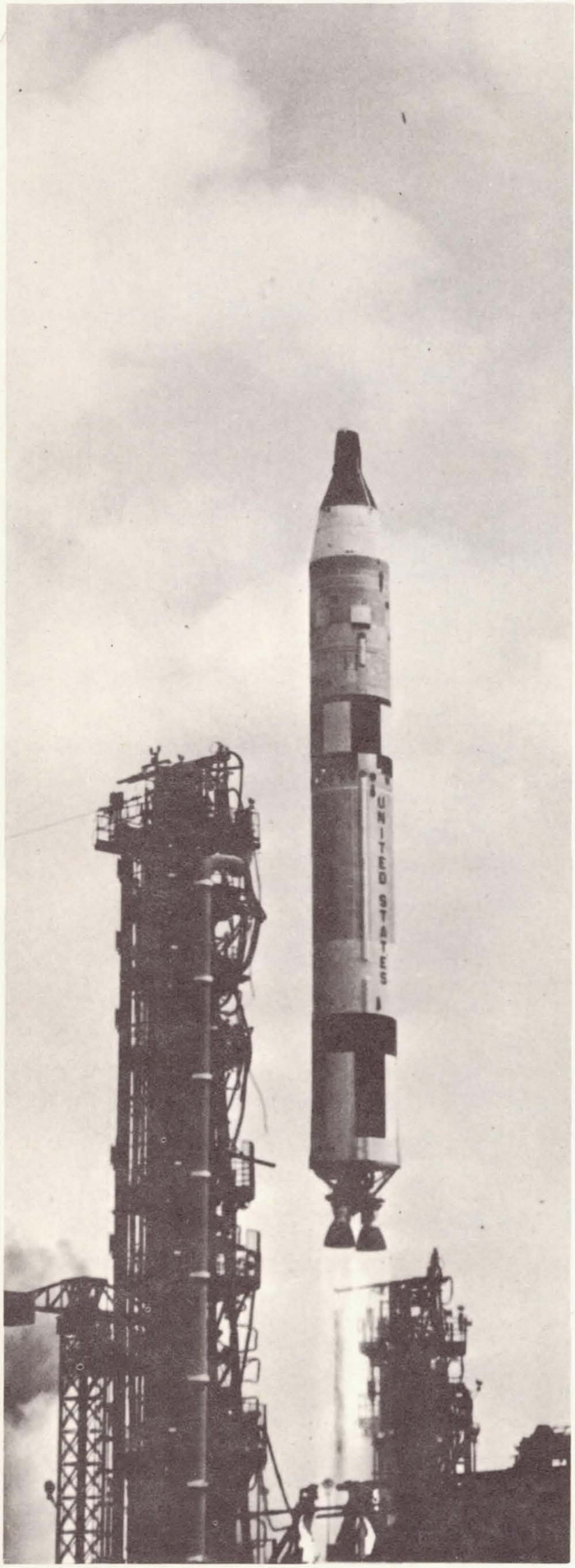
FIRST GEMINI-TITAN FLIGHT (GT–1)

The first Gemini-Titan test flight (GT–1) on April 8, 1964, was an almost perfect lift-off, as Titan boosted the unmanned Gemini craft into orbit from Launch Complex 19 at Cape Kennedy, Fla.

Gemini's apogee (high point of orbit) was 204 miles, perigee (low point) 99.6 miles, and the revolution period around the earth was 89.27 minutes.



Separated segments of Gemini mock-up. At right is docking structure of Agena which contains apparatus for link-up of spacecraft and rocket.



Gemini-Titan launch at Cape Kennedy in April 1964.

In orbit 4 days, the craft came down as calculated on April 12. There was no attempt at recovery since the flight was mainly a structural integrity test for the booster/spacecraft combination, and for its guidance system.

GEMINI EXPERIMENTS

Following GT–1, NASA scheduled a series of scientific, biological, and technological experiments for subsequent Gemini flights. Separate bioastronautics (space medicine) experiments involve the physiological reactions of the astronauts in space.

In "extravehicular activities" experiments, the Gemini astronauts, each in turn, will leave their spacecraft and practice getting around and working in empty space. It is planned that this activity will include tests of specially designed space tools that a weightless astronaut can use without twisting effect.

Capability to leave the craft is afforded by life-support features of the Gemini space suit. While outside of the spacecraft, the astronaut, in effect, will be a "human satellite."

GEMINI SPACECRAFT

The Gemini craft is designed to be *piloted* by its two-man crew. After an automated launch, the Gemini spacemen take over: turning, changing speed, even shifting orbits.

The spacecraft consists of two major portions—the reentry module (package) and the adapter module. The latter, in turn, also has two separate sections, so that Gemini, as launched, is actually a three-part structure.

Only the reentry module returns to earth. This module contains the "living" section where the two astronauts ride.

The life-supporting cabin is double-walled with an inner shell around the crew's pressurized compartment and an outer shell as the craft's external hull.

Between these shells is a storage space for electronic gear and other apparatus—a technological improvement over the Mercury craft, whose components (parts) were "stacked" upon

one another inside the crowded pilot's compartment. In contrast, much Gemini equipment is in the double-walled storage area, where it can be easily checked, adjusted, replaced, even when Gemini is in place atop Titan on the launch pad.

The aft (rear) section contains more equipment, and bottommost is the ablative (melting and evaporating) heat shield that protects the reentry module from air-friction heat on earth-return.

One purpose of the two-part adapter module, which tapers and flares out from 7½ feet to 10 feet in diameter, is to "adapt" (fit) the narrow Gemini to the Titan booster's broad top. Secondly, the adapter's 90-inch deep volume is another housing area for equipment.

The adapter section adjacent to the crew's reentry module is the retrograde assemblage, holding two sets of engines—retrorockets (for reducing speed) and space-maneuvering thrusters.

The adapter's aft part, the equipment section, holds fuel cells, attitude controls, radio units, and a liquid-coolant radiator to dissipate internal spacecraft heat away into open space.

The lower end of this two-part adapter is mated, by means of a metal collar, to the top of the Titan launch rocket.

EJECTION SEAT

Based on a jetplane technique, Gemini's lightweight ejection seats can, in emergency, catapult the astronauts out of two large hinged hatches that open mechanically.

Unlike Mercury's automatic ejection sensors, Gemini's system relies entirely upon the astronaut crew's quick reflexes, because Titan's non-explosive propellants merely burn and allow time for human reactions.

COMPUTER

Among Gemini innovations is a "shoebox" computer, weighing only 57.6 lbs. and occupying a mere cubic foot of cabin space, yet able to make the computations for the intricate rendezvous and docking maneuvers with the orbiting Agena–D.

FUEL CELL

Another "space first" is Gemini's fuel cell, generating electrical power by chemical means. Much lighter than the equivalent batteries they replace, two groups of fuel cells provide 1,000 watts each, supplying the spacecraft's total electrical needs.

GUIDANCE SYSTEM

Aboard Gemini is an ingenious inertial guidance system which records and totals every bit of progress forward, backward, and sideways, from the earth-launch starting point to the space destination.

Linked into the guidance system during orbital maneuvers are other units—computer, radar, electronic controls, attitude thrusters, propulsion units—so that the astronauts' master conrols can accurately achieve rendezvous and docking with Agena.

RENDEZVOUS RADAR

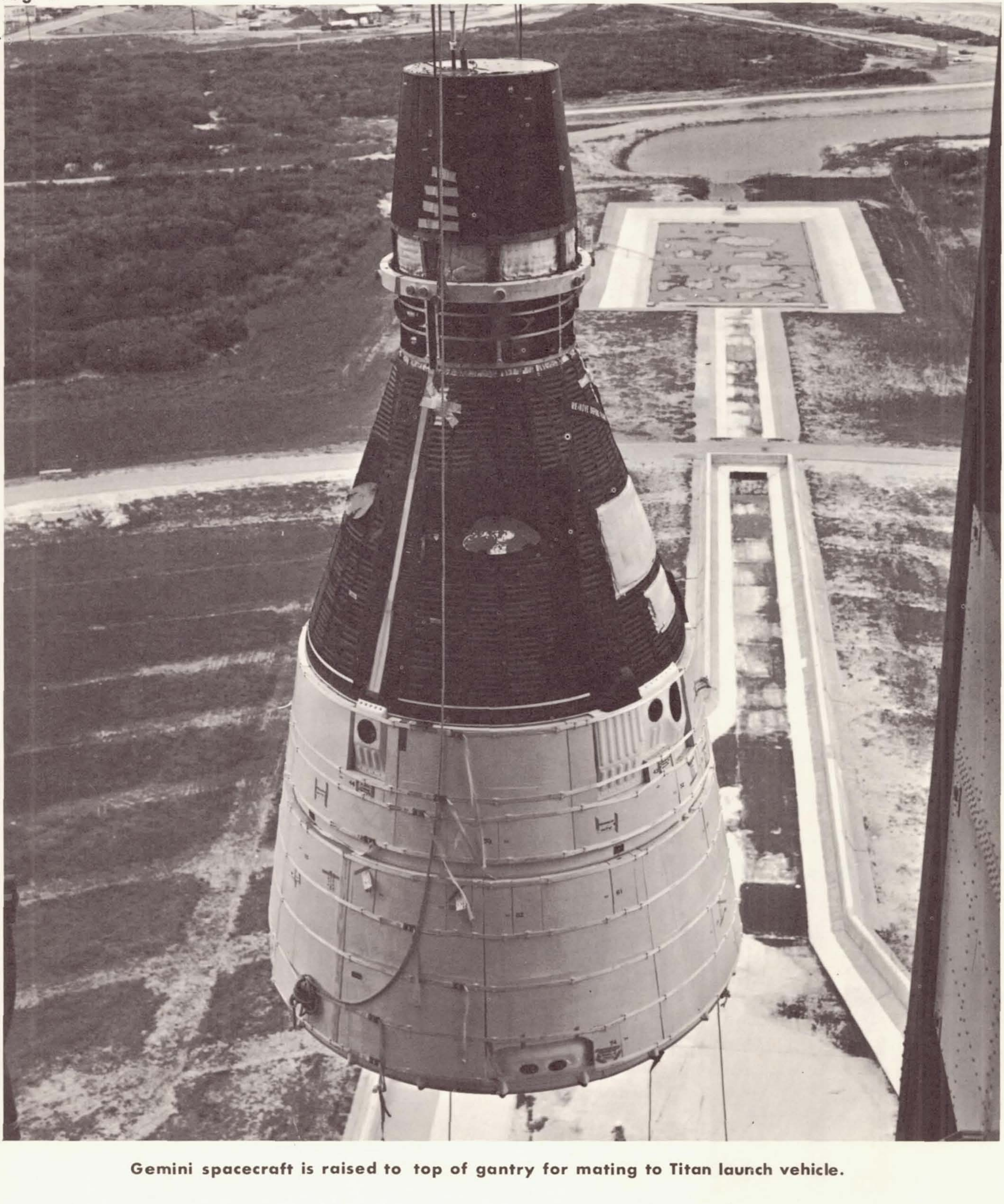
Gemini's high-definition radar gives the range (distance), bearing (direction and angle of approach), and closing speeds of the chase and target vehicles, with data starting when they are 250 miles apart.

Later, the high-intensity flashes of Agena's light beacon become visible to the astronauts, at a maximum range of 50 miles. These optical observations, plus radar tracking, are then combined, as manual controls guide Gemini toward rendezvous with Agena.

Undoubtedly, the Gemini astronauts will eventually blend their own intuitive skills with computer data, and gain the know-how to swing the two vehicles around in space with the routine ease of parking cars on earth.

COMMUNICATIONS SYSTEMS

Three major communications systems are carried aboard Gemini: the voice system, which includes an intercom connection between the astronauts; the receiver of command signals and updated orbit information from Manned Flight Control; data collection tapes and their relay transmitters for automatic transmission of reports to earth.



Gemini spacecraft is raised to top of gantry for mating to Titan launch vehicle.

ENVIRONMENTAL CONTROL SYSTEM (ECS)

The Gemini Environmental Control System in the reentry module's cabin compartment sustains the astronaut pilots and permits them to carry out their duties.

Though the Gemini life-support system is similar to the Mercury ECS, major engineering changes have gone into it. Each astronaut has two parallel suit circuits for oxygen, plus the option of using the cabin's habitable (purified) atmosphere while being partially unsuited for more freedom of action.

Mercury's bottled gas has been replaced in Gemini by a liquid oxygen supply, requiring less storage volume for the maximum 14-day supply.

The third major ECS change is an improved method of dissipating unwanted heat into space.

FOOD AND WATER

Besides being a body fuel, food is important to man as a psychological "uplift."

A basic diet of 2,550 calories per man will be fulfilled by freeze-dried foods including meats, soups, desserts, and fruits. Water restores them to their original form.

Water will be recovered from the atmosphere within the spacecraft, also will be derived as a fuel cell byproduct.

GEMINI LAUNCH VEHICLE

The Gemini launch vehicle is a modification of the military Titan II. Fueled by stable and storable propellants, it is 10 feet wide and 89 feet long (first stage booster 70 feet). The combined Gemini-Titan stands 108 feet high.

An important new Gemini launch vehicle device is the Malfunction Detection System, whose electronic monitors watch the vehicle's performance during launch for possible booster trouble. Warning signals allow ample time for the astronauts to abort (cut short) the mission, if necessary, by using their ejection seats.

AGENA–D TARGET VEHICLE

In the rendezvous of Agena–D and Gemini, the two spacecraft will be joined nose to nose. Hence, after first being orbited, the Agena turns around and goes backwards. Its fore end is thus in docking position as the later-launch Gemini arrives nose first.

Bringing the front ends of two spacecraft together, while whirling around earth at nearly 18,000 mph, is much more difficult than mid-air refueling between a jetplane and a tanker. Hence, the mid-space meeting of rocket vehicles must feature the quickest and most reliable contact via easy-fitting docking devices.

At the Agena's forward end, the target docking adapter (TDA) is a cylindrical collar, within which is a docking cone illuminated by two approach lights. Self-adjusting mechanisms lock firmly to the inserted nose of Gemini and moor the two vehicles.

Prior to docking, an invaluable aid to the astronauts is the lighted status display panel, mounted outside Agena's TDA. Its visual monitors reveal the Agena equipment's operational readiness by means of nine lights and three dials. Typical are green lights for "OK to dock," "PPS TIME" (primary propulsion system), which clocks the amount of burning time left for the main rockets before fuel depletion.

STANDARDIZED SPACE LAUNCH VEHICLE

Historically famous as the booster for six highly sucessful Mercury space flights, the Atlas will also serve as the Agena launch rocket in Gemini's rendezvous experiments.

Known as the Standardized Space Launch Vehicle (SSLV), this 62-foot booster is powered by five conventional liquid rocket engines. Atlas power alone cannot orbit the Agena, and at booster burnout, pyrotechnic devices (explosive bolts) at the SSLV-adapter's forward end release the Agena, whose own engine fires to gain orbital velocity.

LAUNCH CHECKOUTS

Prior to a scheduled Gemini rendezvous mission, all the hardware of two complete launch vehicles and two spacecraft is meticulously checked and rechecked many times over. Because the failure of the tiniest relay or switch

can ruin an entire multimillion dollar space venture—and also risk two human lives—this tediously painstaking checkout procedure is vitally necessary.

All the major vehicles arrive at Cape Kennedy broken down into modules and sections. After dozens of checkouts until all modules are mated into full vehicles, 7 days remain before lift-off. In that week, the final tests include: radio and radar circuits; simulated flight via computer; simulated launch with the two astronauts aboard the spacecraft; servicing and fueling of Titan with checkout of engine systems; complete check of total Gemini Titan equipment; 300-minute dress rehearsal countdown; final 2-day servicing and checkout.

Only after this long parade of cross-check check-outs does the *real* countdown start.

Sharing in all main tests, the two Gemini astronauts gain full confidence that the Titan booster and Gemini spacecraft will successfully bear them into orbit, and safely return them to earth.

The Mission Control Center of MSC, at Cape Kennedy, will monitor early Gemini flights. In later missions, the flight phase will be monitored by a new Mission Control Center at the Manned Spacecraft Center, Houston, Tex.; the launch phase will still be conducted by the Cape Kennedy team.

TRACKING NETWORK

Expanded from the former Mercury network, the Gemini tracking system comprises 13 land stations and two tracking ships, the latter filling landless gaps in the Pacific Ocean.

Besides tracking equipment, all stations have two-way communications with the Gemini spacecraft. Some have additional telemetry equipment or command signal transmitters.

GEMINI RENDEZVOUS MISSION

A Gemini rendezvous mission calls for sending up the Agena target vehicle from Cape Kennedy's Launch Complex 14 approximately 24 hours prior to the Gemini chase vehicle's lift-off from Launch Complex 19.

The Agena is propelled into a circular orbit 185 miles up, after which precise velocity and trajectory elements are calculated. About 24 hours later Gemini blasts off, within the specified "launch window"—the time interval during which launch will produce an orbit permitting the two craft to meet.

Gemini's orbit must be in the same plane (slant toward equator) as Agena's. This restricts the Gemini launch window to about 2 hours in each 24, for the 5-day period the target vehicle can wait for rendezvous. Certain orbit-correcting maneuvers by the Agena, before Gemini launch, can double the launch window.

The basic plan is to maneuver the Gemini into a circular orbit whose altitude is approximately 23 miles less than the Agena.

TARGET CAPTURE

When the distance between vehicles is 250 miles, radar is switched on. As the gap closes to 50 miles, the Gemini astronauts pick up the Agena's flashing beacon and take over the manual controls.

Aiding the astronauts is the status display panel outwardly mounted on the Agena–D, giving visual data on Agena fuel reserves, electrical power, attitude position, all of which is processed through the computer along with the Gemini craft's own movements.

During these maneuvers the relative speed difference between the vehicles has been cut to less than a 2 mph drift rate so that their noses touch gently.

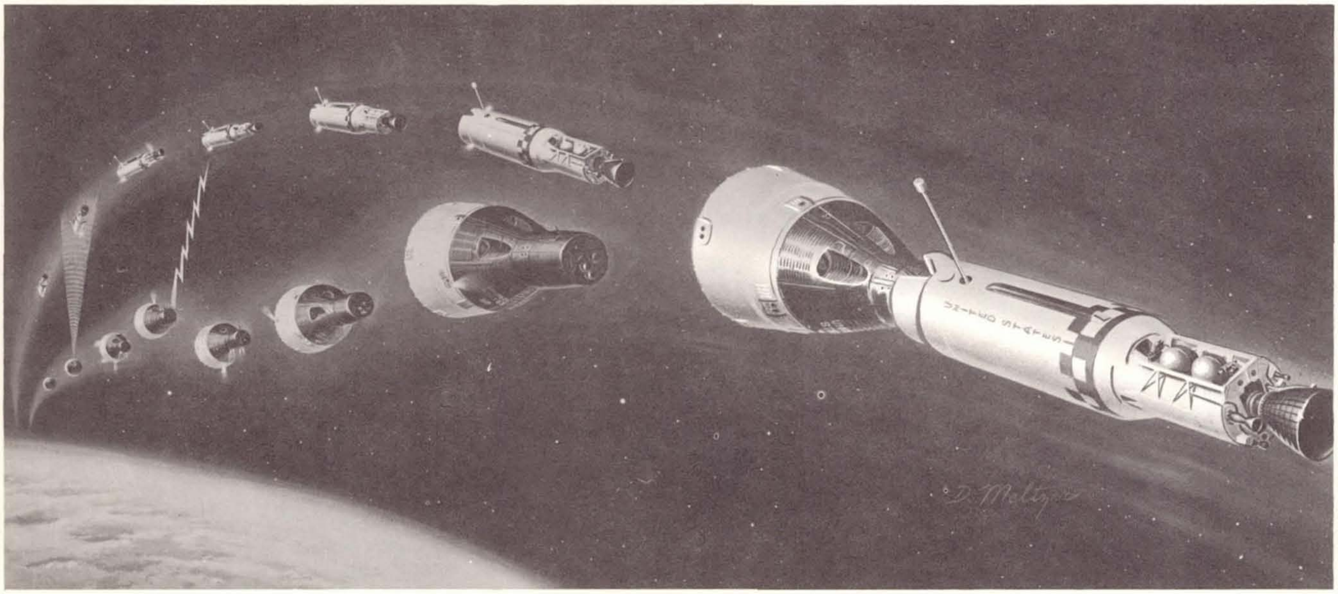
If the first docking maneuver is imperfect, the Agena is merely bumped away and no harm is done. The astronauts simply back off for another try. In a successful contact, the Gemini's narrow end enters the Agena's target docking adapter, whose latches clamp shut to prevent the two vehicles from slipping apart. Then a motorized Agena unit pulls the Gemini nosecone inward all the way.

Once the two craft are tightly moored, matching electrical contacts meet and give the Gemini astronauts direct control of Agena's onboard equipment—guidance, propulsion, attitude control, relay switches, and the rest.

Union of the two vehicles results in a larger Gemini/Agena spacecraft almost 50 feet long, much more powerful and versatile than either of the two original craft. With the main Gemini rockets in back and the Agena thrusters in the front, the two-part Gemini-Agena spacecraft can move either forward or backward without having to turn around. The doubled rocket power also allows for unique space performances through the series of manned Gemini missions.

REENTRY AND RECOVERY

Their rendezvous maneuver completed, the astronauts unhook their Gemini craft from the Agena (left in orbit) and prepare for earth-return. They first ascertain that upon firing the retro-rockets, their downward trajectory will land them in a designated recovery area. This may require orbit corrections by means of their propulsion units.



Scanning the dark sky, Gemini's radar locates Agena at a distance of 250 miles and holds the quarry in view (far left). Gemini's computer determines the approach speed and point at which the two craft will meet. An 8-foot boom antenna on the target craft receives radio signals from the astronauts, who order Agena to assume a stabilized position. Guided by flashing beacons, the astronauts speed up their vehicle and maneuver it toward Agena's cone-shaped docking collar. Though the two craft travel 17,500 miles an hour, their difference in speed is only a little more than one mile an hour at final closure. Crewmen maneuver Gemini's nose into a V-slot in Agena's collar; then mechanical latching fingers snap the craft together. The space-mated couple turn around, placing Agena's restartable engine in position to propel the vehicle into a new orbital path so that the astronauts can probe deeper into space. They will detach Agena before re-entering earth's atmosphere.

Because of Gemini's slight "lift" (gliding ability), there is a capability for "aiming" toward the desired landing site. However, provision is made for the possibility of a random landing; equipment and training for Gemini astronaut survival are more elaborate than they were in Project Mercury.

A survival pack for each Gemini crewman is stowed in a rectangular-shaped cavity in the back of his spacecraft seat. If he leaves the seat, his personal parachute and survival pack—both being strapped to him—are at the same time pulled along.

Gemini spacecraft will have large spacecraft parachutes for water landings, as in Project Mercury.

If reentry is unavoidably over land, the astronauts will eject themselves in the air and parachute down by themselves. The craft's impact on hard ground is too violent for the astronauts to risk, but low enough to prevent serious vehicle damage.

ASTRONAUT SELECTION

The National Aeronautics and Space Administration started with the seven Mercury astronauts in April 1959. For the Gemini and Apollo missions, it chose 9 others in September 1962, and 14 more in October 1963.

There now are 28 astronauts (of the 30 selected) comprising the pool from which the two-man Gemini crews are chosen.

NASA ASTRONAUT TRAINING

All astronauts undergo training to reach peak mental and physical efficiency for Gemini flights. Basic science studies have been expanded to include such courses as computer fundamentals, guidance technology, and astrogation (space navigation).

To prepare for space missions, astronauts practice earth-simulated flights in trainer devices. The space pilot-room simulators teach astronauts the elements of rendezvous and docking by means of electronic dials and dummy controls.

One Gemini flight trainer is located at the Manned Spacecraft Center's new Clear Lake site at Houston, Tex., where the Mission Control Center is also stationed. Another simulator installation is at Cape Kennedy, Fla.

Centrifuges at Johnsville, Pa. and at Ames Research Center in California provide high-g loads to match the stresses of powered launches, training astronauts to handle controls despite acceleration strains.

BIOMEDICAL AND BIOASTRONAUTICS EXPERIMENTS

Gemini flight plans call for various space medicine investigations conceived by NASA's bioastronautics authorities.

In general life-support (bioastronautics) studies, important information to be gained during Gemini missions includes: ways to improve space suits for greater comfort and health; more efficient body waste management; methods of exercising to keep the astronauts in good muscle tone.

A major problem is that the crew of the Gemini, unlike that of the Mercury, will have long periods of zero-g inactivity. These periods might be physically detrimental, unless suitable muscle exercises are developed for the weightless state, plus work-rest cycles that keep spacemen mentally alert.

NASA scientists also face "human engineering" problems involved in space suit design. To alleviate discomfort during confinement for 14-day Gemini trips, parts of the astronaut's suit will be removed for comfort and more free movement.

The GT–3 and GT–4 Gemini crews were chosen early in 1964. From GT–5 on, other paired teams of astronauts take over the assignments.

From among the Gemini astronaut roster, will undoubtedly emerge the three spacemen—unknown as yet—destined to be the first U.S. citizens to fly an Apollo spacecraft to the moon, near the end of this decade.

Those three "lunarnauts" will have an eternal place in history as Columbuses of space who landed on a new world.

Gemini spacecraft mockup being checked out by Astronaut John W. Young.

DEFINITIONS

APOGEE: In an orbit about the earth, the point at which the satellite is farthest from the earth; the highest altitude reached by a sounding rocket.

ASTRONAUTICS: The art, skill, or activity of operating space vehicles. In a broader sense, the science of space flight.

ATTITUDE: The position or orientation of an aircraft, spacecraft, etc., either in motion or at rest, as determined by the relationship between its axes and some reference line or plane such as the horizon.

BALLISTIC TRAJECTORY: The trajectory followed by a body being acted upon only by gravitational forces and the resistance of the medium through which it passes.

BOOSTER ROCKET: A rocket engine, either solid or liquid fuel, that assists the normal propulsive system or sustainer engine of a rocket or aeronautical vehicle in some phase of its flight. A rocket used to set a missile vehicle in motion before another engine takes over.

DOCKING: The process of bringing two spacecraft together while in space.

HYPERGOLIC: Propellants, fuel and oxidizer, which ignite spontaneously upon contact; hydrazine and nitrogen tetroxide are examples.

MODULE: A self-contained unit of a launch vehicle or spacecraft which serves as a building block for the overall structure. The module is usually designated by its primary

(Continued on page 12)

Astronaut Tom Stafford takes his turn in the Gemini Docking Simulator.

DEFINITIONS—*(Continued from page 11)*

function as "command module", lunar landing module, etc. A one-package assembly of functionally associated electronic parts; usually a plug-in unit.

PERIGEE: That orbital point nearest the earth when the earth is the center of attraction.

PITCH: The movement of an aircraft or spacecraft about its lateral (nose going up or down) axis.

PROPELLANT: Any agent used for consumption or combustion in a rocket and from which the rocket derives its thrust, such as a fuel, oxidizer, additive, catalyst, or any compound or mixture of these.

REACTION, ENGINE: An engine that develops thrust by its reaction to ejection of a substance from it; specifically, such an engine that ejects a jet or stream of gases created by the burning of fuel within the engine.

REENTRY: The event occurring when a spacecraft or other object comes back into the sensible atmosphere after being rocketed to altitudes above the sensible atmosphere; the action involved in this event.

RETROROCKET: A rocket fitted on or in a spacecraft, satellite, or the like to produce thrust opposed to forward motion.

ROLL: The rotational or oscillatory movement of an aircraft or similar body which takes place about a longitudinal axis through the body—called "roll" for any amount of such rotation.

SENSOR: The component of an instrument that converts an input signal into a quantity which is measured by another part of the instrument. Also called "sensing element."

SUBORBITAL: Non-orbiting or ballistic flight trajectory from launch point to target point.

TRAJECTORY: In general, the path traced by any body, as a rocket, moving as a result of externally applied forces.

WEIGHTLESSNESS: A condition in which no acceleration, whether of gravity or other force can be detected by an observer within the system in question. A condition in which gravitational and other external forces acting on a body produce no stress, either internal or external, in the body.

YAW: The lateral rotational or oscillatory movement of an aircraft, rocket, or the like about a transverse axis. The amount of this movement, i.e., the angle of yaw.

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